REVIEW

Impact of Different Dietary Patterns on Blood Lipid Levels in Patients With and Without Type 2 Diabetes

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Abstract

Hypercholesterolemia is a well-established risk factor for cardiovascular disease, a common comorbidity in patients with type 2 diabetes (T2D). Individualized dietary regimens are used to achieve therapeutic levels, particularly in patients with T2D. However, the optimal dietary goal to achieve therapeutic glucose and lipid levels remains unclear. This review aims to summarize existing evidence from systematic reviews and meta-analyses evaluating dietary patterns and their effect on blood lipid levels. We found that diets focusing on macronutrient composition are difficult to maintain due to adherence challenges. Although different diets can serve as effective nutritional therapies, a vegetarian diet and the Mediterranean diet are superior in controlling diabetic dyslipidemia and achieving glycemic control. Overall, the Mediterranean diet and plant-based diets have the best evidence for improving glycemic control and selected markers of atherosclerotic cardiovascular disease risks.

Key words: Dietary patterns, lipid levels, diabetes, cardiovascular disease, Mediterranean diet, plant-based diet, moderate fat diet, carbohydrate diet, low fat diet, glycemic index

BACKGROUND

Cardiovascular disease (CVD) is responsible for more than 30% of deaths worldwide. Although significant advances have been made toward understanding its causes, prevention, and treatment, CVD remains a frequent source of morbidity and mortality.[1] Furthermore, CVD is a major health burden in the United States and accounts for a substantial proportion of the countries national health expenditure.[2] More than 81 million US adults have one or more CVD risk factor.[2] In 2010, CVD accounted for an estimated $503.2 billion—an increase from $287 billion in 2008—in annual total direct and indirect costs.[2] A substantial number of epidemiological and clinical studies show that CVD risks are associated with blood lipid derangement, especially low-density lipoprotein cholesterol (LDL-C). As a result, the National Cholesterol Education Program, the American Heart Association (AHA), and other governing agencies have issued guidelines that define LDL-C as the principal target of therapy, as well as the LDL-C level at which diet and medication therapy should be initiated.[3,4] Dyslipidemia is a significant risk factor for CVD, ischemic stroke, nonalcoholic fatty liver disease, and chronic pancreatitis.[5] It often coexists with other metabolic syndromes, including obesity and type 2 diabetes (T2D).[5]

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CITATION:
Boaful G, George P. Impact of different dietary patterns on blood lipid levels in patients with and without type 2 diabetes. *Consultant*. Published online March 12, 2021. doi:10.25270/con.2021.03.00008

Received August 11, 2020. Accepted December 28, 2020.

DISCLOSURES:
The authors report no relevant financial relationships.

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Several epidemiological and clinical studies note that risk factors of deranged lipid and lipoprotein levels are heavily dependent on lifestyle habits.[6] To improve the lipid profile, the AHA recommends low-cost therapeutic lifestyle modifications such as physical activity and prudent diet.[7] The AHA reports that heart-healthy lifestyle choices are the foundation of prophylactic treatment for atherosclerotic cardiovascular disease (ASCVD) risk.[7,8] Many studies have been conducted to assess the impact of dietary patterns on the improvement of ASCVD risk. One dietary pattern that has been successful is the Dietary Approaches to Stop Hypertension (DASH) diet, promoted by the National Institutes of Health, to treat hypertension without medication.[9] The focus has now shifted to dietary patterns in order to improve lipid profiles based on the results of the DASH diet, along with the results of many studies that have demonstrated that dietary patterns generate greater improvements in health outcomes compared with diets based on macronutrient composition.[9,10]

The goal of this review is to integrate published evidence from systematic reviews and meta-analyses evaluating dietary patterns with emphasis on plant-based, low/moderate fat, low/moderate carbohydrate, low glycemic index, and Mediterranean diets on the control of hypercholesterolemia and its complications.

METHODS

A literature search of PubMed and Google Scholar was conducted for systematic reviews and meta-analyses, randomized controlled trials (RCTs), and reviews. References of previously identified studies were also searched for additional studies. Selected studies were those that compared different dietary patterns and assessed their role on blood lipids and lipoproteins. The search strategy had no date restrictions and included search terms such as "dietary patterns," "plant-based," "low/moderate fat," "low/moderate carbohydrate," "low glycemic index," "Mediterranean (diet)," "hypercholesterolemia," and "dyslipidemia" in different combinations. Studies were considered eligible for inclusion if they were carried out in adults (≥ 18 years of age) and compared different diets in participants with and without T2D.

RESULTS

Plant-Based Diets

The definition of plant-based diet is variable. In the literature, the term has encompassed not only vegetarian or semi-vegetarian diets (ie, pescatarian, macrobiotic) but also vegan diets.[11] "Vegan" and "vegetarian," however, cannot be used interchangeably. Vegan diets allow all animal food products, including meat, dairy, eggs, and so on, whereas vegetarian diets exclude all animal-derived products. Of note, some vegetarian diets allow eggs, dairy products, or a combination of both.[11]

Several RCTs have been conducted to examine the impact of plant-based diets on the control of elevated lipid levels. One systematic review and meta-analysis assessed the effect of dietary approaches on blood lipid levels.[12] A total of 52 RCTs were included, involving 5360 adults with T2D. The vegetarian diet was compared with other diets, including low/moderate carbohydrate, low glycemic index/glycemic load, low fat, and high protein diets. The vegetarian diet was found to significantly lower LDL-C (mean difference [95% CI], -0.33 mmol/l) and high-density lipoprotein cholesterol (HDL-C) compared with a control diet.[12] The LDL-C association is of high importance, as it is presently the target of lipid-lowering therapy. A decrease in LDL-C facilitates a decrease in ASCVD risk.

Another systematic review evaluated dietary patterns and management of T2D.[13] RCTs comparing vegetarian diets with traditional diabetic diets (50% carbohydrate, 20% protein, and < 30% fat) were analyzed. The vegetarian diet was found to significantly reduce diabetes medication use (43% for the vegetarian group and 5% for the control group), increase glycemic control, and reduce body weight by an average 6.2 kg for the intervention group and by an average 3.2 kg for the control group.[13] The vegan diet was found to significantly lower total cholesterol, LDL-C, and hemoglobin A1c (HbA1c).[13] Another analysis showed that the vegetarian diet was superior in terms of glycemic control and lipid profile but not in weight loss at 18 months' follow-up.[14]

Although these studies involved adults with diabetes, the benefits of vegan and vegetarian diets extend to healthy adults without diabetes as well. Plant-based diets may serve as a beneficial alternative to nutritional therapy, the authors concluded. But they also called for additional studies to explore the long-term effects of these diets.[14]

Low-Fat and Moderate-Fat Diets

A low-fat diet is defined as a diet that contains less than 30% fat of total energy intake, high intake of cereals and grains, and 10% to 15% of protein intake.[12] Results of a meta-analysis provided a distinction between low-, moderate-, and reduced-fat diets.[15] A reduced-fat diet is when the energy from saturated fatty acids is replaced by carbohydrates. A moderate-fat diet is when saturated fatty acids are replaced with unsaturated fatty acids. A low-fat diet is when the saturated fatty acid level is reduced without any energy replacement.[15]

This meta-analysis of controlled trials assessed the effect of moderate- vs low-fat diets on lipid and lipoprotein concentrations.[15] The analysis included a total of 30 controlled-feeding studies, involving 1213 participants with and without diabetes, over a period of 2 to 12 weeks. The moderate-fat diet provided an average 30.2% to 50.0% of energy, and the low-fat diet provided an average 18.3% to 30.2% of energy.[15]

The moderate-fat diet was found to significantly lower LDL-C, triglycerides, and the triglycerides:HDL-C ratio.[15] It also decreased non-HDL-C and increased apolipoprotein A-1 and HDL-C compared with the low-fat diet. The moderate-fat

diet was also associated with reduced congestive heart disease (CHD) risk in men and women.[15] In participants with T2D, the changes were more pronounced. For instance, with the moderate-fat diet, triglyceride levels had decreased by 224.79 mg/dL, triglycerides:HDL-C ratios had decreased by 0.62, and non–HDL-C levels had decreased by 25.39%.[15] Similarly, the reduction in CHD risk was more prominent in men (17.6%) and women (18.5%) who consumed the moderate-fat diet vs those who consumed the low-fat diet. The low-fat diet showed similar findings but at a reduced magnitude. Conversely, the low-fat diet had increased triglyceride levels.

Data about the long-term effects of many diets is scant, as several dietary studies are performed over short periods. This often generates unanswered questions about the long-term impact of dietary patterns. A systemic review and meta-analysis evaluated the long-term effects of low-fat diets compared with high-fat diets.[16] A total of 32 studies were included in the analysis. Consuming the low-fat diet had shown a pronounced decrease in triglyceride and LDL-C levels. The high-fat diet induced significant increases in HDL-C and reductions in triglyceride levels.[16]

The evidence implies that, compared with low-fat diets, moderate-fat diets may more effectively lower triglyceride levels, triglycerides:HDL-C ratio, non-HDL-C, and CHD risk in patients with and without diabetes. Definitive recommendations cannot be made about the long-term effects of low-fat diets vs high-fat diets, since both produced clinically acceptable outcomes in the lipid profile. This result gives credence to the urgency of more long-term studies to thoroughly assess clinical significance.

Low-Carbohydrate and Moderate-Carbohydrate Diets

A 2019 systematic review defined a low-carbohydrate diet as a diet with carbohydrate intake of less than 45% of total energy intake.[13] Another study defined it as carbohydrate intake of less than 25% of total energy intake, fat intake of more than 30% of total energy intake, and high intake of animal and/or plant protein.[12] Furthermore, a moderate-carbohydrate diet was defined as carbohydrate intake of 25% to 45% of total energy intake and protein intake of 10% to 20%.[12] The systematic review of RCTs assessed different dietary patterns and management of T2D.[13] A total of 20 RCTs were included in the analysis. In comparing low-carbohydrate and low-fat diets, the researchers found that neither diet had significantly improved lipid control, weight, or CVD risk factors. However, the low-carbohydrate diet was found to significantly lower HbA1c levels.[13] The researchers noted that the low-carbohydrate diet provided greater benefits over the short term with no superiority observed over the long term. They surmised that difficulty with strict adherence to a low-carbohydrate diet in a real-world setting may have contributed to this outcome.[13] This also lends additional support to the shift in focus from diets based on macronutrient composition to unique dietary patterns.

Another systemic review and meta-analysis examined the role of different dietary patterns in the management of T2D.[14] It included 20 RCTs involving 3073 adult participants. The low-carbohydrate diet induced a significant decrease in HbA1c percentage, an increase in HDL-C, a non-statistically significant decrease in LDL-C, and a reduction in triglyceride levels.[14] The clinical significance of these changes is unclear, as the changes are small, and there were appreciable inconsistencies.

Moreover, variant forms of the low-carbohydrate diet are being investigated. Of note is the low-carbohydrate Mediterranean diet. One group of researchers reported that the low-carbohydrate Mediterranean diet generated a 23% reduction in the risk of diabetes compared with the low-fat diet, in addition to a protective effect against inflammation, insulin resistance, and metabolic syndrome.[13] Likewise, the researchers reported marked improvement in coronary disease risk factors along with reductions in HbA1c.[13] Furthermore, partial or complete remission of diabetes was noted in 14.7% of participants within the first year of intervention and another 5% of participants after 6 years. The researchers also noted decreased triglyceride levels by an average 1.3 mmol/L and improved glucose levels.[13] The researchers argued that these changes were likely due to the Mediterranean diet component, which places greater emphasis on fruit, vegetables, nuts, and legumes and less emphasis on red meat. Another systematic review and meta-analysis compared the moderate-carbohydrate diet with other diets.[12] The moderate-carbohydrate diet was found to significantly reduce LDL-C but had no effect on HDL-C.[12]

The evidence suggests modification of macronutrient composition has a role in the management of patients with and without diabetes based on improved glycemic control and lipid profiles. The inconsistencies in the analysis and the lack of benefits in the long term necessitates longer-term studies to learn about the diets' impact in a real-world setting. Additionally, the variation in definition of the carbohydrate diets could be a source of heterogeneity, which in isolation can contribute to the inconsistencies in the analysis. Sources of heterogeneity in studies should be explored, as they affect the clinical significance of study results.[17] Similarly, the marked increase in positive benefits observed with the low-carbohydrate Mediterranean diet indicates that the Mediterranean diet may be superior to the low-carbohydrate diet.

Low Glycemic Index Diet

Glycemic index dietary patterns have been found to be effective at enhancing glycemic control. However, the evidence has thus far been inconsistent. A glycemic index diet is commonly defined in the literature as the area under the curve (AUC) 2-hour blood glucose response after the ingestion of 50 g of carbohydrates. The AUC of the test food is divided by the AUC of the standard (usually glucose or white bread) and multiplied by 100.[14]

One systematic review and meta-analysis assessed the effect of low glycemic index diet on the management of T2D.[14] A total of 20 RCTs were included, involving 3073 participants with T2D. The low glycemic index diet was found to significantly lower HbA1c and increase HDL-C. Effects on LDL-C and triglyceride levels were not significant compared with controls.[14]

Another study reported that when low glycemic index/glycemic load diet was compared with other diets, the low glycemic index/glycemic load diet induced significant reductions in LDL-C.[12] Another meta-analysis of RCTs assessed the effect of the low glycemic index diet on the management of T2D.[18] For this study, the researchers compared the low glycemic index diet with conventional or high glycemic index diets. The analysis included 14 RCTs and 356 patients with type 1 or 2 diabetes. The low glycemic index diet was found to significantly reduce HbA1C by 0.43 percentage points compared with the high glycemic index diet.[18]

Mediterranean Diet

The Mediterranean diet is considered a plant-based diet, although it is not by strict definition. It is the most studied dietary pattern and is recognized as a component of many dietary guidelines. Its beneficial effects are not restricted to the Mediterranean diet alone.[1] Even when components of the Mediterranean diet are added to other dietary regimens, the components tend to enhance the positive effects of the other diet regimen. An example is the low-carbohydrate Mediterranean diet explained above. It reduces chronic inflammation and insulin resistance and creates a protective effect in patients with metabolic syndrome.[13]

Features of the Mediterranean diet comprise vegetables, legumes, fruits, nuts, and whole grain in addition to fish, seafood, and poultry. Additional components include olive oil and low intake of meat and meat products.[19] One systematic review and meta-analysis assessed the effects of different dietary patterns on the management of T2D.[14] It included 20 RCTs, involving 3073 participants. The Mediterranean diet was found to significantly lower HbA1c, help achieve weight loss more effectively vs control diets, reduce triglyceride levels, and increase HDL-C.[14]

For another systemic review and meta-analysis, the researchers assessed the effects of dietary patterns on blood lipid control in patients with T2D.[12] The results were consistent with the results discussed above. It included 52 RCTs, involving 5360 adult participants. The Mediterranean diet was found to effectively increase HDL-C and decrease triglyceride levels.[12] In their statistical analysis, the researchers also assessed a relative ranking of the different diets to determine the cumulative effect of all the diets on diabetic dyslipidemia. The Mediterranean diet had the highest cumulative score, implying that it was the most effective dietary pattern to manage diabetic dyslipidemia.[12]

Another meta-analysis and systemic review summarized the importance of the Mediterranean diet in the prevention and management of T2D.[19] The results demonstrated that the Mediterranean diet was more effective at decreasing body weight, HbA1c, and oxidative stress. It was also found to significantly increase HDL-C.[19]

The evidence indicates that the Mediterranean diet or its components—fruits, vegetables, nuts, legumes, high fibers, high monounsaturated fatty acids, high magnesium, high potassium, and high antioxidant and anti-inflammatory macronutrients, as well as reduced intake of saturated fatty acids, heme iron, sodium, nitrites, and nitrates—are health promoting.[11] The antioxidant and anti-inflammatory benefits lower the risk of vascular injury and atherosclerosis. In patients with diabetes, benefits of the Mediterranean diet can curtail microvascular and macrovascular complications.

CONCLUSION

This summary of the existing evidence from systematic reviews and meta-analyses demonstrates that multiple diets may be effective in achieving glycemic control and promoting cumulative reductions in ASCVD risk factors. It also supports the organizational shift from diets based on macronutrient composition to distinctive dietary patterns, such as Mediterranean or vegan diets, as these specific dietary patterns deviate from nutrient-counting, thus promoting ease of adherence by patients.

Additionally, the overall evidence suggests that dietary behaviors are often personal, and the challenges for clinicians are implementing a dietary pattern that fits a patient's unique dietary preferences, baseline knowledge of different dietary forms and dietary strategies, and any potential access restrictions.[10] Our review suggests that the Mediterranean diet and plant-based diets have the best evidence for improving glycemic control and certain markers of CVD risks, demonstrated by reductions in blood lipid profiles, blood pressure, HbA1c, and LDL-C in patients with and without diabetes. These improvements are often limited to reductions in CVD risks. There remains a need for large, long-term RCTs that assess whether these benefits translate to reductions in CVD outcomes. Nonetheless, the evidence for the Mediterranean diet and plant-based diets for improving cardiometabolic health remains a strong potential opportunity.

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